CLAIMS

1. A method for transferring information within a cellular communications network, comprising acts of :

transmitting an optical carrier from a first network-element of the network;

modulating the optical carrier with the information;

detecting the modulated optical carrier in an avalanche photo-diode (APD) comprised in a second network-element of the network so as to recover the information; and

altering a gain of the APD responsive to a level of the optical carrier so as to prevent saturation of the APD.

2. A method according to claim 1, wherein the act of transmitting the optical carrier comprises transmitting coherent radiation from a laser diode.

3. A method according to claim 1, wherein the act of transmitting the optical carrier comprises transmitting incoherent radiation from a light emitting diode.

4. A method according to claim 1, wherein the act of modulating the optical carrier comprises modulating the carrier with one or more sub-carriers comprising the information.

5. A method according to claim 1, wherein the act of detecting the modulated optical carrier comprises measuring an output level generated by the APD, and wherein altering the gain of the APD responsive to the level comprises altering the gain responsive to the output level.

6. A method according to claim 5, wherein the act of measuring the output level comprises utilizing a central processing unit (CPU) comprised in the second network-element to measure an average output level, and wherein altering the gain responsive to the output level comprises utilizing the CPU to alter the gain.

7. A method according to claim 1, wherein the act of detecting the modulated optical carrier comprises measuring an output level of the APD, and wherein transmitting the optical carrier comprises varying a power level of the optical carrier responsive to the output level of the APD.

8. A method according to claim 7, wherein the act of varying the power level of the optical carrier comprises:

transmitting a reverse optical carrier from the second network-element to the first network-element;

modulating the reverse optical carrier with an indication of the output level of the APD; and

varying the power output responsive to the indication.

9. A method according to claim 8, further comprising the act of modulating the reverse optical carrier with additional information.

10. A method according to claim 1, wherein the act of transmitting the optical carrier comprises transmitting the optical carrier via a path between the first network-element and the second network-element comprising free space.

11. A method according to claim 1, wherein the act of transmitting the optical carrier comprises transmitting the optical carrier via a path between the first network-element and the second network-element comprising a fiber optic.

12. A method according to claim 1, further comprising the act of altering the gain of the APD responsive to at least one of an optical background noise level of the optical carrier and an aggregate system noise, so as to prevent saturation of the APD.

13. Apparatus for transferring information within a cellular communications network, comprising:

a first network-element of the network, comprising:

an emitter which is adapted to transmit an optical carrier; and

a modulator which is adapted to modulate the optical carrier with the information; and

a second network-element of the network, comprising:

an avalanche photo-diode (APD) which is adapted to detect the modulated optical carrier so as to recover the information; and

a gain controller which is adapted to alter a gain of the APD, responsive to a level of the optical carrier, so as to prevent saturation of the APD.

14. Apparatus according to claim 13, wherein the emitter comprises a laser diode which transmits coherent radiation.

15. Apparatus according to claim 13, wherein the emitter comprises a light emitting diode which transmits incoherent radiation.

16. Apparatus according to claim 13, wherein the modulator is adapted to modulate the optical carrier with one or more sub-carriers comprising the information.

17. Apparatus according to claim 13, wherein the gain controller comprises a detector which is adapted to measure an output level generated by the APD, and wherein the gain controller is adapted to alter the gain of the APD responsive to the output level.

18. Apparatus according to claim 17, wherein the second network-element comprises a central processing unit (CPU) which is adapted to measure the output level as an average output level, and to alter the gain responsive to the average output level.

19. Apparatus according to claim 13, wherein the gain controller is adapted to measure an output level of the APD, and wherein the emitter is adapted to vary a power output of the optical carrier responsive to the output level of the APD.

20. Apparatus according to claim 19, wherein the second network-element comprises a reverse-transmitting emitter which is adapted to transmit a reverse optical carrier which conveys an indication of the output level of the APD from the second network-element to the first network-element, and wherein the emitter is adapted to vary the power output responsive to the indication.

21. Apparatus according to claim 20, wherein the second network-element comprises a reverse modulator which modulates the reverse optical carrier with additional information.

22. Apparatus according to claim 13, wherein the emitter is adapted to transmit the optical carrier via a path between the first network-element and the second network-element comprising free space.

23. Apparatus according to claim 13, wherein the emitter is adapted to transmit the optical carrier via a path between the first network-element and the second network-element comprising a fiber optic.

24. Apparatus according to claim 13, wherein the gain controller is adapted to alter the gain of the APD responsive to at least one of an optical background noise level of the optical carrier and an aggregate system noise, so as to prevent saturation of the APD.

25. Apparatus for transferring information within a cellular communications network, comprising:

a first network-element of the network, comprising:

a first amplifier which is adapted to receive and amplify a radio-frequency (RF) signal so as to generate a first-amplified-RF-signal;

a detector which indicates attainment of a predetermined level of the received-RF-signal;

a first gain device which is adapted to alter a gain of the first amplifier by a predetermined gain-value responsive to the attainment of the predetermined level; and

an optical transmitter which modulates an optical carrier with the first-amplified-RF-signal and which transmits the modulated carrier; and

a second network-element of the network, comprising:

an optical receiver which receives the modulated carrier and generates a recovered-RF-signal therefrom;

a second amplifier which is adapted to receive and amplify the recovered-RF-signal so as to generate a second-amplified-RF-signal; and

a second gain device which is adapted to alter a gain of the second amplifier by a value substantially equal to a negative of the predetermined gain-value responsive to the attainment of the predetermined level at the first network-element.

26. Apparatus according to claim 25, wherein the detector generates a change-gain signal responsive to the attainment of the predetermined level, and wherein the optical transmitter conveys the change-gain signal to the optical receiver.

27. Apparatus according to claim 26, wherein the second network-element comprises a central processing unit (CPU) which incorporates the second gain device into the second amplifier responsive to the received change-gain signal.

28. Apparatus for receiving information transmitted in a cellular communications network, comprising:

an optical assembly which is adapted to receive an optical carrier modulated with the information and output the received-modulated-carrier;

a first optical unit which is coupled to receive the received-modulated-carrier at a first end of the first optical unit and to convey the received-modulated-carrier therein;

a first receiver which is coupled to a second end of the first optical unit to receive a first fraction of the received-modulated-carrier and which, responsive thereto, is adapted to generate a first output representative of the information;

a second optical unit which is coupled to the first optical unit so as to convey a second fraction of the received-modulated-carrier into the second optical unit;

a second receiver which is coupled to the second optical unit so as to receive the second fraction of the received-modulated-carrier and which, responsive thereto, is adapted to generate a second output representative of the information; and

a switch which selects from the first and the second outputs responsive to a level of the received-modulated-carrier.

29. Apparatus according to claim 28, wherein a ratio of the first fraction to the second fraction is comprised in an approximate range between 30:1 and 300:1.

30. Apparatus according to claim 28, and comprising:

a third optical unit which is coupled to the second optical unit so as to convey a third fraction of the received-modulated-carrier into the third optical unit; and

a third receiver which is coupled to the third optical unit so as to receive the third fraction of the received-modulated-carrier and which, responsive thereto, is adapted to generate a third output representative of the information,

and wherein the switch selects from the first, second, and third outputs responsive to the level of the received-modulated-carrier.

31. Apparatus according to claim 30, wherein a ratio of the second fraction to the third fraction is comprised in an approximate range between 30:1 and 300:1.

32. Apparatus according to claim 28, and comprising:

a third optical unit which is coupled to the first optical unit so as to convey a third fraction of the received-modulated-carrier into the third optical unit; and

a third receiver which is coupled to the third optical unit so as to receive the third fraction of the received-modulated-carrier and which, responsive thereto, is adapted to generate a third output representative of the information,

and wherein the switch selects from the first, second, and third outputs responsive to the level of the received-modulated-carrier and to an ability to operate of the second and third receivers.

33. Apparatus according to claim 28, wherein at least one of the first and second optical units comprises a fiber optic.

34. Apparatus for transferring information within a cellular communications network, comprising:

a first network-element of the network, comprising:

an analog-to-digital converter (ADC) which is adapted to convert a radio-frequency (RF) signal to a digital signal, the RF signal being receivable from a transceiver operative within the network;

an optical modulator which is coupled to receive the digital signal and is adapted to modulate an optical carrier with the signal; and

a transmitter which is adapted to transmit the modulated optical carrier; and

a second network-element of the network, comprising:

a receiver which is coupled to receive the modulated optical carrier;

a demodulator which is adapted to recover the digital signal from the modulated optical carrier; and

a digital-to-analog converter (DAC) which is adapted to convert the digital signal so as to recover the RF signal.

35. Apparatus according to claim 34, wherein a sampling rate of the ADC is equal or greater than approximately twice a frequency of the RF signal bandwidth.

36. Apparatus according to claim 34, wherein the digital signal comprises a compressed digital signal generated by the ADC, and wherein the DAC is adapted to decompress the compressed digital signal.

37. Apparatus for transferring information within a cellular communications network, comprising:

a first network-element of the network, comprising:

a splitter, which is adapted to receive an initial radio-frequency (RF) signal comprising the information and to split the signal into a first RF signal and a second RF signal;

a first optical transmitter which is coupled to modulate a first optical carrier with the first RF signal and to transmit the first modulated optical carrier; and

a second optical transmitter which is coupled to modulate a second optical carrier with the second RF signal and to transmit the second modulated optical carrier;

a second network-element of the network, comprising:

a first optical receiver which is adapted to receive and demodulate the first modulated optical carrier to recover the first RF signal;

a second optical receiver which is adapted to receive and demodulate the second modulated optical carrier to recover the second RF signal; and

a summer which is coupled to add the first and second recovered RF signals so as to regenerate the initial RF signal; and

a first feedback network, coupling the first optical receiver to the first optical transmitter, which alters a first characteristic of the first modulated optical carrier responsive to a first parameter indicative of a first quality of information transferred by the first modulated optical carrier measured at the second network-element.

38. Apparatus according to claim 37, and comprising a second feedback network which couples the second optical receiver to the second optical transmitter, and which alters a second characteristic of the second modulated optical carrier responsive to at least one of a second parameter indicative of a second quality of information transferred by the second modulated optical carrier measured at the second network-element and the first parameter.

39. Apparatus according to claim 37, wherein a level of the first RF signal is different from the level of the second RF signal.

40. Apparatus according to claim 37, wherein a frequency of the first RF signal is different from the frequency of the second RF signal.

41. Apparatus according to claim 37, wherein a parameter of the first modulated optical carrier is different from the parameter of the second modulated optical carrier, wherein the parameter is chosen from a group comprising a wavelength, a polarization, and a power level.

42. Apparatus according to claim 37, wherein the first modulated optical carrier comprises substantially analog modulation, wherein the first characteristic comprises at least one of a bandwidth and a level of the first modulated optical carrier, and wherein the first parameter comprises a signal-to-noise ratio of the first modulated optical carrier.

43. Apparatus according to claim 37, wherein the first modulated optical carrier comprises substantially digital modulation, wherein the first characteristic comprises at least one of a bandwidth and a level of the first modulated optical carrier, and wherein the first parameter comprises a bit-error-rate of the first modulated optical carrier.

44. Apparatus for transferring information within a cellular communications network, comprising:

a first network-element of the network, comprising:

a first mixer which is adapted to modulate a first RF sub-carrier with a first RF signal;

a second mixer which is adapted to modulate a second RF sub-carrier with a second RF signal;

a summer which is coupled to add the first and second modulated sub-carriers to generate a combined RF signal; and

an optical transmitter which is coupled to transmit an optical carrier modulated with the combined RF signal; and

a second network-element of the network, comprising:

an optical receiver which is adapted to receive the modulated optical carrier and to recover the combined RF signal;

a splitter which is coupled to recover from the combined RF signal the first modulated sub-carrier and the second modulated sub-carrier as separate signals;

a third mixer which is adapted to receive the first modulated sub-carrier and to recover the first RF signal; and

a fourth mixer which is adapted to receive the second modulated sub-carrier and to recover the second RF signal.

45. Apparatus according to claim 44, wherein the third mixer receives the first RF sub-carrier so as to recover the first RF signal, and wherein the fourth mixer receives the second RF sub-carrier so as to recover the second RF signal.

46. A method for transferring information within a cellular communications network, comprising the acts of:

receiving and amplifying, in a first amplifier comprised in a first network-element of the network, a radio-frequency (RF) signal so as to generate a first-amplified-RF-signal;

altering a gain of the first amplifier by a predetermined gain-value, responsive to the RF signal attaining a predetermined level;

modulating an optical carrier with the first-amplified-RF-signal and transmitting the modulated carrier;

receiving in an optical receiver comprised in a second network-element of the network the modulated carrier and generating a recovered-RF-signal therefrom;

receiving and amplifying the recovered-RF-signal in a second amplifier so as to generate a second-amplified-RF-signal; and

altering a gain of the second amplifier by a value substantially equal to a negative of the predetermined gain-value, responsive to the RF signal attaining the predetermined level.

47. A method according to claim 46, and further comprising the acts of generating a change-gain signal in the first network-element responsive to the RF signal attaining the predetermined level, and conveying the change-gain signal to the second network-element.

48. A method for receiving information transmitted in a cellular communications network, comprising the acts of:

receiving in an optical assembly an optical carrier modulated with the information and outputting therefrom the received-modulated-carrier;

coupling the received-modulated-carrier into a first end of a first optical unit and conveying the received-modulated-carrier therein;

receiving a first fraction of the received-modulated-carrier in a first receiver coupled to a second end of the first optical unit and responsive thereto generating a first output representative of the information;

coupling a second optical unit to the first optical unit;

conveying a second fraction of the received-modulated-carrier into the second optical unit;

receiving in a second receiver coupled to the second optical unit the second fraction of the received-modulated-carrier and, responsive thereto, generating a second output representative of the information; and

selecting between the first and the second outputs responsive to a level of the received-modulated-carrier.

49. A method according to claim 48, wherein the acts of coupling comprise forming a ratio of the first fraction to the second fraction that is comprised in an approximate range between 30:1 and 300:1.

50. A method according to claim 48, wherein at least one of the first and second optical units comprises a fiber optic.

51. A method for transferring information within a cellular communications network, comprising the acts of:

converting, in an analog-to-digital converter (ADC), a radio-frequency (RF) signal to a digital signal, the RF signal being receivable by a transceiver operative within the network;

modulating an optical carrier with the digital signal; and

transmitting the modulated optical carrier from a transmitter comprised in a first network-element of the network; and

receiving and demodulating the modulated optical carrier in a receiver comprised in a second network-element of the network, so as to recover the digital signal; and

converting the digital signal in a digital-to-analog converter (DAC) so as to recover the RF signal.

52. A method according to claim 51, wherein the act of converting comprises sampling at a sampling rate of the ADC that is equal to or greater than approximately twice a frequency of the RF signal.

53. A method according to claim 51, wherein the act of converting in the ADC comprises compressing the digital signal to form a compressed digital signal and the act of converting in the DAC comprises decompressing the compressed digital signal.

54. A method for transferring information within a cellular communications network, comprising the acts of:

receiving an initial radio-frequency (RF) signal comprising the information and splitting the signal into a first RF signal and a second RF signal;

modulating a first optical carrier with the first RF signal to produce a first modulated optical carrier and transmitting the first modulated optical carrier from a first optical transmitter in a first network-element of the network;

modulating a second optical carrier with the second RF signal to produce a second modulated optical carrier and transmitting the second modulated optical carrier from a second optical transmitter in the first network-element;

receiving in a first optical receiver in a second network-element of the network the first modulated optical carrier and demodulating the first modulated optical carrier to recover the first RF signal;

receiving in a second optical receiver in the second network-element the second modulated optical carrier and demodulating the second modulated optical carrier to recover the second RF signal;

coupling the first optical receiver to the first optical transmitter by a first feedback network which alters a first characteristic of the first modulated optical carrier, responsive to a first parameter indicative of a first quality of information transferred by the first modulated optical carrier measured at the second network-element; and

adding the first and second recovered RF signals to regenerate the initial RF signal.

55. A method according to claim 54, and comprising the act of coupling the second optical receiver to the second optical transmitter by a second feedback network which alters a second characteristic of the second modulated optical carrier, responsive to at least one of a second parameter indicative of a second quality of information transferred by the second modulated optical carrier measured at the second network-element and the first parameter.

56. A method according to claim 54, wherein the act of splitting comprises providing a level of the first RF signal that is different from the level of the second RF signal.

57. A method according to claim 54, wherein the act of splitting comprises providing a frequency of the first RF signal that is different from the frequency of the second RF signal.

58. A method according to claim 54, wherein the acts of modulating comprise providing a parameter of the first modulated optical carrier that is different from a parameter of the second modulated-optical carrier, wherein the parameter is chosen from a group comprising a wavelength, a polarization, and a power level.

59. A method according to claim 54, wherein the first modulated optical carrier comprises substantially analog modulation, wherein the first characteristic comprises at least one of a bandwidth and a level of the first modulated optical carrier, and wherein the first parameter comprises a signal-to-noise ratio of the first modulated optical carrier.

60. A method according to claim 54, wherein the first modulated optical carrier comprises substantially digital modulation, wherein the first characteristic comprises at least one of a bandwidth and a level of the modulated first optical carrier, and wherein the first parameter comprises a bit-error-rate of the first modulated optical carrier.

61. A method for transferring information within a cellular communications network, comprising the acts of:

modulating a first RF sub-carrier with a first RF signal to form a first modulated sub-carrier;

modulating a second RF sub-carrier with a second RF signal to form a second modulated sub-carrier;

adding the first and second modulated sub-carriers to generate a combined RF signal;

transmitting an optical carrier modulated with the combined RF signal from a first network-element of the network;

receiving the modulated optical carrier in a second network-element of the network and recovering the combined RF signal;

separating the combined RF signal into the first modulated sub-carrier and the second modulated sub-carrier;

recovering the first RF signal from the first modulated sub-carrier; and

recovering the second RF signal from the second modulated sub-carrier.

62. A method for allocating capacity to a network-element operating in a cellular communications network, comprising the acts of:

providing a plurality of spatially fixed network-elements, each network-element having a respective capacity for transmitting and receiving signals compatible with the cellular communications network;

coupling pairs of the plurality of network-elements by respective optical carriers, each carrier being modulated so as to convey the signals between the respective coupled pair of network-elements; and

transferring at least some of the capacity of the coupled network-elements therebetween via the optical carriers, responsive to a level of the signals detected by the plurality of network-elements.

63. A method according to claim 62, wherein the spatially fixed network-elements are implemented to operate a plurality of cellular systems, and wherein transferring at least some of the capacity comprises transferring capacity between the cellular systems, and wherein the plurality of cellular systems comprises any of systems operating on two or more frequency bands, systems operating by two or more multiplexing methods, and systems operated by two or more different operators.

64. Apparatus for allocating capacity in a cellular communications network, comprising:

a first plurality of spatially fixed network-elements, each network-element having a respective capacity for transmitting and receiving signals compatible with the cellular communications network; and

a second plurality of optical carriers, each carrier coupling a pair of the network-elements and being modulated so as to convey the signals therebetween, and being adapted to transfer at least some of the capacity of the coupled network-elements therebetween, responsive to a level of the signals detected by the network-elements.

65. A method for transferring information within a cellular communications network, comprising the acts of:

transmitting an optical carrier from a first network-element of the network to a second network-element of the network;

modulating the optical carrier with the information so as to transfer the information from the first network-element to the second network-element;

transmitting a pilot signal from the first network-element to the second network-element;

measuring a received power level of the pilot signal at the second network-element;

generating a mapping between the received power level of the pilot signal and a parameter indicative of a quality of the information transferred from the first network-element to the second network-element; and

adjusting at least one of a transmitted power level of the optical carrier and a communication bandwidth of the optical carrier, responsive to the received power level of the pilot signal and the mapping, so as to maintain a predetermined minimum quality of the information transferred from the first network-element to the second network-element.

66. A method according to claim 65, wherein the act of transmitting the pilot signal comprises transmitting an optical pilot signal substantially collinearly with the optical carrier, and with a wavelength substantially different from the wavelength of the optical carrier.

67. A method according to claim 65, wherein the act of transmitting the pilot signal comprises transmitting a pilot channel as a sub-carrier on the optical carrier.

68. A method according to claim 65, wherein the act of modulating the optical carrier comprises modulating the optical carrier with an analog modulation, and wherein the parameter indicative of the quality comprises a signal-to-noise ratio of the optical carrier.

69. A method according to claim 65, wherein the act of modulating the optical carrier comprises modulating the optical carrier with a digital modulation, and wherein the parameter indicative of the quality comprises a bit error rate of the optical carrier.

70. Apparatus for transferring information within a cellular communications network, comprising:

a first network-element of the network, comprising:

an optical emitter which transmits an optical carrier modulated with the information as a modulated optical carrier;

a pilot signal generator which transmits a pilot signal; and

a first central processing unit (CPU) which controls the emitter and the pilot generator;

a second network-element of the network, comprising:

a transducer which receives the modulated optical carrier and generates recovered information therefrom;

a detector which measures a received power level of the pilot signal;

a second CPU which receives the measured power level; and

a memory which stores a mapping between the received power level of the pilot signal and a parameter indicative of a quality of the recovered information, at least one of the first and second CPUs being adapted to adjust at least one of a transmitted power level of the optical carrier and a communication bandwidth of the optical carrier, responsive to the received power level of the pilot signal and the mapping, so as to maintain a predetermined minimum quality of the recovered information.

71. Apparatus according to claim 70, wherein the pilot signal comprises an optical pilot signal which is transmitted substantially collinearly with the modulated optical carrier, and which comprises a wavelength substantially different from the wavelength of the modulated optical carrier.

72. Apparatus according to claim 70, wherein the pilot signal comprises a pilot channel operative as a sub-carrier on the optical carrier.

73. Apparatus according to claim 70, wherein the modulated optical carrier comprises an analog modulation, and wherein the parameter indicative of the quality comprises a signal-to-noise ratio of the modulated optical carrier.

74. Apparatus according to claim 70, wherein the modulated optical carrier comprises a digital modulation, and wherein the parameter indicative of the quality comprises a bit error rate of the modulated optical carrier.